Wave Climate and Beach Nourishment

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Looking to the future, beach nourishment projects will involve significantly more detailed descriptions of the wave climate of a site and a more complete understanding of the coastal processes. Empirical techniques will be replaced by more complete wave descriptions and process-based methodologies.

The recent experience of Baird & Associates with beach nourishment projects has demonstrated to us the importance of defining the directional distribution of wave energy. We have found that one parameter to describe wave direction is insufficient and often misleading. For some projects there are many instances of waves occurring from two different sources at one time. Typically, this may be locally generated waves and swell waves but it may also be waves from two remote sources. We have also realized that for many ocean shorelines, swell waves from the opposite hemisphere, while of very low steepness, may control sand transport and must be considered.

The north coast of the Sultanate of Oman (known as the Batinah coast) faces the Gulf of Oman to the northeast (see Figure 1). The available wave data (ship observations) show that the dominant wave directions come from the north and observations for the winter monsoon, with its northerly winds, confirmed this. Consequently, harbors were designed to provide protection from the north with entrance channels facing to the east. The problem with this conclusion is that site observations clearly show that the transport is directed from southeast to northwest, against the waves as it were.

We have now shown that swell waves propagate into the Gulf of Oman from the east, and were generated in the Indian Ocean. Clearly these swell waves that are hardly visible at sea because of their low steepness dominate with respect to sand transport. Therefore, a definition of the wave climate of this region for the purpose of sand transport must include directional spectra and be able to separate sources of energy should they occur at the same time.

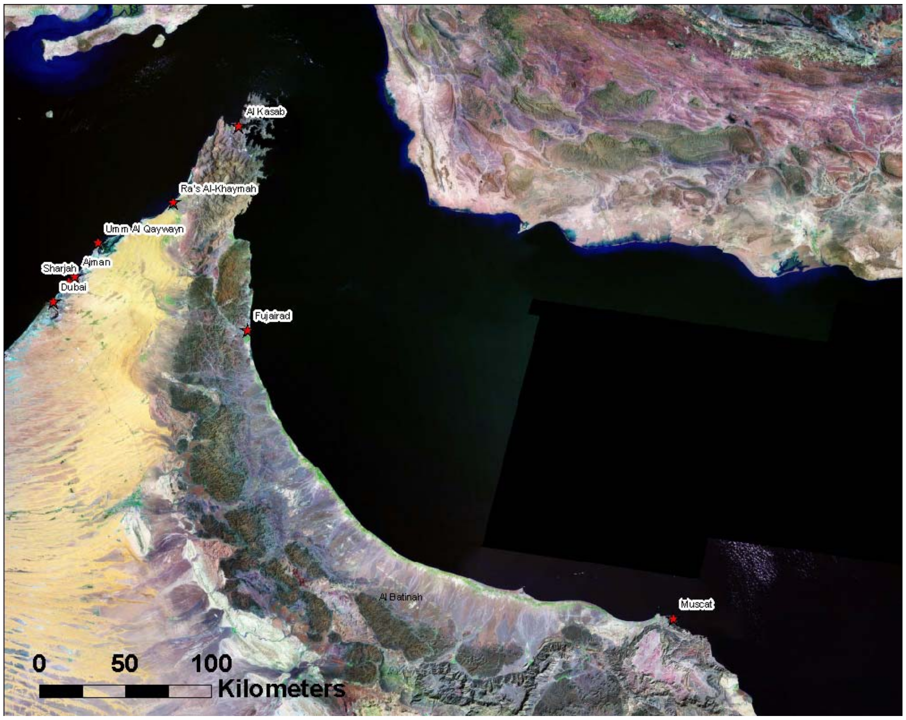

Figure 1 – Location Map of the Batinah Coast of Oman (between Muscat and Fujairah)

The shore protection component of the Keta Sea Defence Project in Ghana, West Africa consists of six 190 m long headlands pre-filled with 2.6 million m^3 of sand. Being a Design-Build project, there has been tremendous opportunity and need to monitor the response of the beaches to the construction of the large headlands. The monitoring consists of a directional wave buoy with real-time information, shoreline position and nearshore profile surveys. The wave monitoring also provided a basis for testing and validating the development of a 40-year wave climate and complex nearshore transformation. The deepwater wave generation was completed using the US Army Corps of Engineers WAVAD model. The waves that reach this site located just north of the equator (5 degrees North) are generated at latitudes of 40 to 65 degrees South and travel 4000 to 6000 km prior to reaching the site. Therefore, to develop the wave climate for the site it was necessary to model the entire South Atlantic Ocean (see Figure 2). Nearshore wave transformations were completed with three different models including MIKE21 NSW, STWAVE and a Spanish model, GHOST. The improved wave information resulted in excellent comparisons to the quantity of sand trapped updrift of the headlands. The revised estimates of longshore sand transport and the long-term temporal variability resulted in revisions to the original design. An overview of these issues will be presented in the presentation.

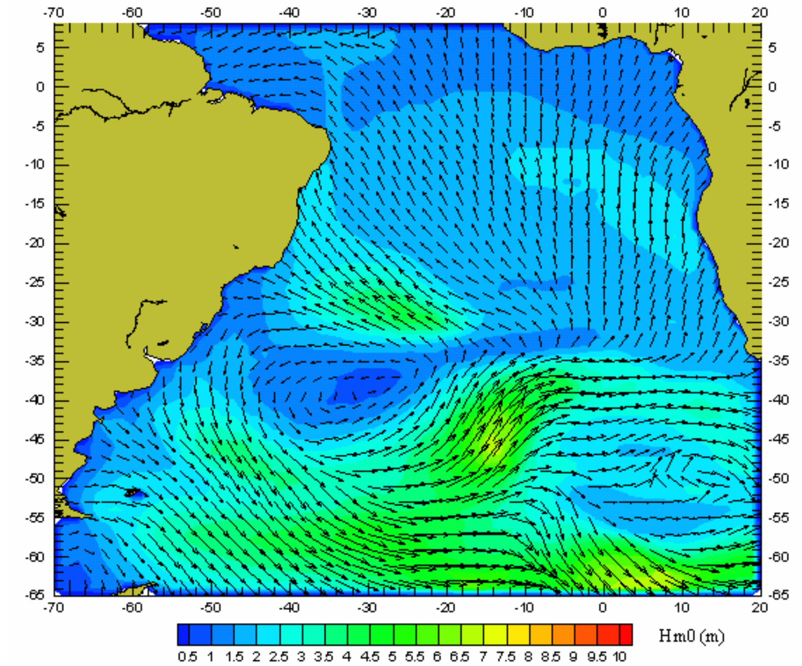

Figure 2 – Snapshot of the WAVAD Model Output for the South Atlantic Simulation.

These recent experiences demonstrating the ability to predict accurately long term wave climates suggest that a more process-based approach could be used to evaluate the performance of beach nourishment projects in the future. In addition, an understanding of climatic oscillations and their influence on long term temporal variability of the wave climate (and net sand transport rates) at a site could prove important to consider for projections of future performance of beach nourishment projects.